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Macroeconomic Adjustment to Oil Shocks and Fiscal Reform

Simulations for Zimbabwe, 1988-95

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and
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Deep fiscal reform will significantly help Zimbabwe achieve a sustainable debt path, a decline in interest rates paid on public debt, and a recovery of private consumption and investment.

This paper — a product of the Macroeconomic Adjustment and Growth Division, Country Economics Department — is part of the division's development of RMSM-XX, an applied macroeconomic general equilibrium model for policy simulations and economic projections. Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Susheela Jonnakuty, room N11-049, extension 39074 (94 pages). September 1991.

Elbadawi and Schmidt-Hebbel develop and apply a macroeconomic general equilibrium model for Zimbabwe. The model integrates a behavioral estimated model structure, taken from a companion paper, with the relevant budget constraints for a six-sector disaggregation into a comprehensive framework.

Starting with 1988 as a base year, they present simulations for a base scenario covering the period 1988-95. From the different macroeconomic issues and reform requirements identified in the companion paper as relevant for Zimbabwe today, they select two for performing alternative scenario simulations here: a continuation of the current oil shock and strong fiscal stabilization.

The oil shock is shown to reduce growth, increase inflation, depreciate the real exchange rate, and reduce private investment in Zimbabwe, a country heavily dependent on imported oil.

Fiscal adjustment is a major challenge for stabilization and growth faced by Zimbabwe's policymakers today. The paper's simulations show that deep fiscal reform will significantly help Zimbabwe achieve a sustainable debt path, a decline in interest rates paid on public debt, and a recovery of private consumption and investment.

(See companion paper, "Macroeconomic Structure and Policy in Zimbabwe: Analysis and Empirical Model, 1965-88," WPS 771.)

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1. INTRODUCTION

This paper develops and uses a macroeconomic general equilibrium model for Zimbabwe. The behavioral model structure is based on a companion piece (Elbadawi and Schmidt-Hebbel, 1991), which lays out in detail the specification and estimation results for goods and assets markets. This paper adds to the latter a detailed stock-flow consistent budget constraint structure for a 6-sector disaggregation, parameterized for the 1988 base year. It also discusses alternative closure rules and general equilibrium properties of the model.

Our companion paper identifies the main issues and policy requirements relevant for Zimbabwe's current macroeconomic situation and its future stability and growth prospects. This paper selects two of these issues to carry out simulations which address them: the uncertainty associated to the current oil shock and the need for fiscal adjustment.

Section II presents the complete model structure, divided by budget constraints and related equations and the behavioral structure for goods and assets markets. Section III discusses in detail alternative closure rules for macroeconomic models in general and presents the closure choices and general equilibrium properties of the Zimbabwe model. Section IV discusses external environment and policy assumptions for a base scenario which combines a mild transitory oil shock and unchanged fiscal policies and structural features of the Zimbabwean economy. The 1988-95 base scenario simulation results are presented and discussed in detail. Section V presents simulation results for two alternative scenarios. The first assumes a worsening external environment resulting from a prolongation and deepening of the current oil price shock. Simulation results for 1988-95 are also performed for a major fiscal adjustment, carried throughout the 1991-95 period. Section VI concludes.

2. A MACROECONOMIC GENERAL EQUILIBRIUM (RMSM-XX) MODEL FOR ZIMBABWE

This section discusses in detail the model structure of the Zimbabwe RMSM-XX macroeconomic model.

The specification of any macroeconomic model requires to make decisions in three areas: sector disaggregation, market disaggregation, and behavioral and closure rules. The decisions in these areas, based on the economy's structure, the use of the model, and macroeconomic theory, give rise to the three main building blocks of a macroeconomic model: sector budget constraints, market equilibrium conditions, and behavioral equations/selection of endogenous variables, the latter determined by the closure rule decided for the model. One should note that the budget constraints and market equilibrium conditions are independent of the chosen closure rule. In particular, the market equilibrium conditions are specified independently of having instantaneous market clearing achieved by flexible prices or fix-price equilibria with quantity adjustment. The latter choice is reflected by the decision in the third area: closure rule (the selection of endogenous/exogenous variables) and behavioral equations (the structure of demands and supplies).

The macroeconomic specification chosen for Zimbabwe, reflected by particular decisions in these three areas which give rise to the corresponding building blocks, is summarized in diagram 2.1. Six agents comprise our economy: the budgetary (or central) government (b), the other public sector (o, comprised by public enterprises and local government), the central bank (cb, the Reserve Bank of Zimbabwe), the commercial banking sector (bs, the consolidated deposit banks), the non-financial private sector (p), and the external sector (f, the rest of the world). This disaggregation is consistent with data availability¹,

¹ A data base for the other public sector, collected by Walton (1988), used by Khadr et al (1989), and extended by Schmidt-Hebbel (1990), is available. No systematic data is available for disaggregating the non-financial private sector into households and firms.

DIAGRAM 2.1
STRUCTURE OF ZIMBABWE RMSM-XX MODEL

I. AGENTS OR SECTORS

Consolidated Non-Financial Public Sector	{	1. Budgetary Government	}	Consolidated Total (Fin. and Non-Fin.)
Monetary System	{	2. Other Public Sector		Public Sector
		3. Central Bank	}	Consolidated Total
		4. Comm. Banking System		Private Sector
		5. Non-Financial Private		
		6. External Sector		

Budget Constraints

II. MARKETS

1. Goods Markets: Domestic Goods
 Imported Goods
2. Assets Markets: Foreign Assets and Liabilities
 Domestic Monetary Assets and Liabilities
 Domestic Non-Monetary Assets and Liabilities

MARKET EQUILIBRIUM CONDITIONS

III. BEHAVIORAL RULES

1. Market Clearing in Goods and Assets Markets at Endogenous Goods Prices and Assets Returns
2. Behavioral Specification of Goods and Assets Demand and Supplies
3. Alternative Closure Rules for External Financing and Domestic Financing of Public Sector

SELECTION OF ENDOGENOUS VARIABLES
BEHAVIORAL EQUATIONS
DEMANDS/SUPPLIES

the structure of the Zimbabwean economy², and the relevant questions to be addressed by the model. With regard to the latter, our disaggregation allows to address directly issues of monetary and domestic debt financing of public sector deficits, by constructing consolidated total public sector outstanding debt stocks. These are obtained by aggregating the b, o and cb sectors into the consolidated total (financial and non-financial public sector and the bs and p sectors into the consolidated total (financial and non-financial) private sector. On the other side, consolidation of cb and bs into the monetary system allows to relate "ultimate" monetary (base money) and non-monetary (total consolidated interest-bearing) public debt holdings to "intermediate" financial holdings of the non-financial private sector (M1 and quasi-money).

Goods markets are disaggregated into domestic (or national or Zimbabwean) goods and imported goods. Domestic goods are all goods produced at home, hence GDP is equal to the supply of domestic goods. Having only one good on the production side, it is not necessary to distinguish between domestic final and intermediate goods supply, although the production of the domestic good requires intermediate imports. Demand (for consumption and investment, by the public and private sectors) falls on domestic and national goods. Demand decisions on the composition between domestic and imported goods and supply decisions on intermediate imports determine total import demand; therefore there is no need for specifying independent import equations. Finally, a foreign demand for exports (which are undistinguishable from other domestic goods on the supply side, reflecting a large-country assumption for exports) completes the goods market structure.

Asset markets are disaggregated into 10 foreign assets and liabilities, 4 monetary assets (currency, bank reserves, M1 and quasi-money) and 12 non-monetary interest-bearing assets. The relatively high number of

² Zimbabwe has a well-developed commercial banking sector and a sizable public enterprise sector. These features justify treating the first sector separately from the central bank (as opposed to the Zimbabwe RMSM-X model which aggregates the commercial banking sector and the central bank into one monetary sector) and the second sector separate from the non-financial private sector (where it would stay implicitly if not treated explicitly).

monetary/financial assets is consistent with the intersectoral capital account financing flows among the economy's 6 agents. The economy's aggregate physical capital stock is the only physical asset. No labor markets are considered in our model.

With regard to behavioral rules, the model assumes continuous market clearing in the main goods and asset markets. Within-period adjusting domestic goods prices (the GDP deflator) clear the market for domestic goods, the within-period adjusting public bond interest rate clears the market for domestic public debt, and the within-period adjusting interest rate on quasi-money (time and banking deposits) clears the market for quasi-money. These three central, pivotal (relative) prices and returns act as anchors for many other prices and interest rates. Domestic prices of imported goods are given by PPP rules, being proportional to the exogenously fixed nominal exchange rate (which acts as the nominal price anchor or numeraire), international prices, and tariff rates. Some prices of domestic-good aggregate demand components are determined exogenously. Most interest rates of domestic interest-bearing assets are anchored to the above-mentioned rates. Interest rates of foreign assets and liabilities are set exogenously.

The behavioral specification of goods and assets demands and goods supply, based fundamentally on Elbadawi and Schmidt-Hebbel (1991), reflects standard eclectic specification practices combining neoclassical and Keynesian elements under backward-looking expectations, as discussed in that paper. Finally, the discussion of alternative closure rules and the model's general equilibrium properties is postponed until section 3.

The six sectors' budget constraints and related equations are introduced in the next subsection, followed by the presentation of market equilibrium conditions and behavioral equations for goods and asset markets.

TABLE 2.1

VARIABLE DEFINITIONS

Sector specific variables and intersectoral flows are represented by the following subindices:

b	Budgetary Government
o	Other Public Sector
cb	Central Bank (Reserve Bank of Zimbabwe)
bs	Commercial Banking Sector (Consolidated Deposit Banks)
p	Non-financial Private Sector
f	External Sector

Intersectoral flows list first the paying sector and second the receiving sector, (for instance, Nbp denotes net interest payments paid by b to p), unless the variable identifies one of the two sectors. For instance, COG_b is the current transfers from abroad; i.e. from f to b.

Asset or liability stocks are distinguished from flows by adding the prefix S to the former. For example, SM₁ is the current-period M₁ stock, while M₁ denotes the current-period flow -- the difference between SM₁ and SM_{1,-1}.

Liability stocks denote first, the sector holding the liability and next the issuer, (for instance, SLpb is the stock of loans held by the private sector and issued by the budgetary government), unless the stock variable identifies either the holder or issuer. For example, SNOLcb denotes the stock of net other liabilities held by the private sector and issued by the central bank.

Interest rates denote the holder and issuer in the same order followed by the liability stocks above. For instance, i_{pb} is the interest rate paid by the budgetary government to the private sector; hence $N_{bp} = i_{pb} * SL_{pb,-1}$.

The prefix R denotes a revaluation effect (capital gains/losses from nominal exchange rate depreciation).

National-accounts subindices are as follows:

c	consumption
i	fixed investment
dom	domestic (or national) good
imp	imported goods
mint	intermediate imports
exp	exports

The supra index * denotes an external, foreign currency (US\$) denominated variable.

The following list introduces variable definitions in alphabetical order. In general, lower-case letters denote constant-price variables and upper-case letters represent current price variables.

B	consolidated total public sector debt held by p
c	consumption
chst	change in stocks
COG	current transfers from abroad
DFI	direct foreign investment
dom	domestic goods
DRS	depreciation and retained surplus of o
DY	current disposable income of p
DYp	permanent disposable income of p

TABLE 2.1

(Cont.)

E	average-period nominal exchange rate (Z\$/US\$)
E*	end-of-period exchange rate
EO	errors and omissions
exp	exports
FA	foreign assets
FL	foreign liabilities
fi	fixed investment
grp	growth rate of prices
H	monetary base
imp	imported goods
sh	share variable
K	physical capital stock
KOG	capital transfers from abroad
Knei	capital flows not elsewhere included
L	loans
LS	short-term loans from f to p
mint	intermediate imports
M1	sum of currency and demand deposits
N	interest payments
NFA	interest payments on FA
NFL	interest payments on FL
NIMF	interest payments on IMF
Nknei	interest payments on Knei
NNOL	interest payments on NOL
NOL	Net other liabilities held by p
NS	interest payments on LS
OthR	Other revenue of b from p
P	GDP deflator; domestic price index
QM	quasi-money
Res	reserves of bs at cb
Resid	net current-account surplus of financial institutions
PR	profit remittances
pro	private sector profits
S	saving
\hat{P}_{ip}^e	t-expected private fixed investment inflation in t+1
Sub	subsidies to p
pg	productivity gains
T	current transfers to p (with subindices)
T	time counter
ta	ad valorem tariff rate
Td	direct taxes
Ti	indirect taxes
WI	wage index
y	GDP
Yf	factor income
yp	potential output

2.1 Budget Constraints

The within-period (or flow) budget constraints for the six sectors are introduced next, following closely the structure of equations of the RMSM-X models (see in particular Ventura (1990) and Khadr et al. (1990) for Zimbabwe). Each sector's budget constraint is split into two equations: one for the difference between current-account sources and uses of funds (equal to above-the-line saving) and the second for the difference between capital-account uses and sources of funds (equal to below-the-line saving). All variables, defined in table 2.1, are measured in current-price, local currency units, unless otherwise specified. The following equations (A1.1) - (A1.12) constitute the set of 12 budget constraints.

Budgetary Government:

$$(A1.1) \quad Yf_b + Td + Ti + Resid_{cb} + OthR + COG_b + N_{ob} - P_{cb} \\ - c_b - Sub_b - T_{bo} - T_{bp} - N_{bcb} - N_{bbs} - N_{bpb} - N_{bfb} = S_b$$

$$(A1.2) \quad P_{ib} f_{ib} + L_{bo} - KOG_b - L_{cbb} - L_{bsb} - L_{pb} - L_{fb} = S_b$$

Other Public Sector:

$$(A1.3) \quad DRS + T_{bo} + COG_o - P_{co}C_o - Sub_o - T_{op} - N_{rb} - N_{ocb} \\ - N_{obs} - N_{op} - N_{o.} = S_o$$

$$(A1.4) \quad P_{io} fi_o - KOG_o - L_{bo} - L_{cbo} - L_{bso} - L_{po} - L_{fo} = S_o$$

Central Bank:

$$(A1.5) \quad N_{bcb} + N_{ocb} + N_{bscb} + N_{pcb} + NFA_{cb} - NRES - NNOL_{cb} \\ - NFL_{cb} - NIMF - Resid_{cb} = S_{cb}$$

$$(A1.6) \quad L_{cbb} + L_{cbo} + L_{cbbs} + L_{cbp} + FA_{cb} + RFA_{cb} - Res \\ - Cu - NOL_{cb} - FL_{cb} - RFL_{cb} - IMF - RIMF = S_{cb}$$

Commercial Banks:

$$(A1.7) \quad N_{bbs} + N_{obs} + N_{Res} + N_{pbs} + NFA_{bs} - N_{bs\ cb} - N_{QM} \\ - N_{NOLbs} - NFL_{bs} - Resid_{bs} = S_{bs}$$

$$(A1.8) \quad L_{bsb} + L_{bso} + Res + L_{bsp} + FA_{bs} + RFA_{bs} - L_{cbbs} \\ - (M1-CU) - QM - NOL_{bs} - FL_{bs} - RFL_{bs} = S_{bs}$$

Private Sector:

$$(A1.9) \quad Yf_p + T_{bp} + T_{op} + T_{fp} + Resid_{bs} + COG_p + N_{bp} + N_{op} \\ + N_{NOLcb} + N_{QM} + N_{NOLbs} - P_{cp} C_p - Td - OthR - PR \\ - N_{pcb} - N_{pbs} - N_{pf} - NS_{pf} - Nknei = S_p$$

$$(A1.10) \quad P_{ip} fi_p + P_{chst} chst + L_{pb} + L_{po} + NOL_{cb} + M1 + QM + NOL_{bs} \\ - KOG_p - DFI - L_{cbp} - L_{bsp} - L_{fp} - LS_{fp} - Knei - EO = S_p$$

External Sector:

$$(A1.11) \quad P_{imp} imp - P_{exp} exp - COG_b - COG_o - COG_p - T_{fp} + PR \\ + N_{bf} + N_{of} + NFL_{cb} + NIMF + NFL_{bs} + N_{pf} + NS_{pf} \\ + Nknei - NFA_{cb} - NFA_{bs} = S_f$$

$$\begin{aligned}
 (A1.12) \quad & KOG_b + KOG_o + KOG_p + DFI + L_{fb} + L_{fo} + FL_{cb} + RFL_{cb} \\
 & + IMF + RIMF + FL_{bs} + RFL_{bs} + L_{fp} + LS_{fp} + Knei \\
 & + EO - FA_{cb} - RFA_{cb} - FA_{bs} - RFA_{bs} = S_f
 \end{aligned}$$

As an implication of Walras' law, one equation of the complete set of equations comprised by the budget constraints introduced here and the market equilibrium conditions introduced below, is redundant. For our model we choose this to be the external sector budget constraint (the balance of payments equation). Hence its two components, equations (A1.11) and (A1.12), are listed above for accounting completeness, not for determining any endogenous variable in the Zimbabwe RMSM-XX model.

Assumptions on the monetary system

While government accounts are generally defined on a cash basis, the external, national and monetary accounts are typically on an accruals basis.³ This paper does not attempt to solve this inconsistency, implying that the residual sector in constructing the data base (the private sector) implicitly reflects discrepancies between accrual and cash flows from other sectors. However, one particular source of differences between accrual and cash flows is addressed by our framework: capital gains and losses due to exchange rate variations. With regard to this particular accruals source, the budget constraints of the central bank and the commercial banking sector are defined on accruals basis, while the four non-bank sectors' budget constraints are defined on cash basis. The reason for this is that the source of information for deriving the capital account flows for the former two sectors is the balance sheets of these sectors. To insure consistency between these two accruals-basis budget constraints and the cash-basis budget constraints of the other four sectors, the changes in the domestic-currency values of foreign assets and

³ See Host-Madsen (1979) for a more detailed discussion.

liabilities held by cb and bs are decomposed into the foreign-currency (or cash) asset accumulation and the capital gain (or loss) due to a depreciation of the nominal exchange rate.⁴

Another feature of the two monetary-system sectors, shared with the RMSM-X models, is the assumption that saving is zero in each of them. The difference between gross interest receipts and payments is assumed to be fully paid by cb to the budgetary government ($Resid_{cb}$) and by bs to the non-financial private sector ($Resid_{bs}$). The zero-saving assumption is simply:

$$(A2.1) \quad S_{cb} = 0$$

$$(A2.2) \quad S_{bs} = 0$$

Interest Payments

Domestic-currency interest payments from sector j to sector k on liability SL issued by j and held by k are defined as:

$$(A3.*) \quad N_{jk} = i_{kj} SL_{kj, -1}$$

In the case of interest payments on foreign assets or liabilities (i.e. when either j or k are substituted by f), the domestic-currency value of the outstanding foreign-currency liability is valued at the preceding end-of-period nominal exchange rate:

$$SL_{kj, -1} = E_{-1}^* SL_{kj, -1}^*$$

⁴ The changes in outstanding asset and liability holdings of the cb and bs sectors include accrued non-realized capital gains and losses due to changes in asset prices. In order to obtain consistency between these two sectors' accruals-basis budget constraints and the other sectors' cash-basis budget constraints, we have to deal explicitly with one source of capital gains/losses: the gains (losses) on foreign-asset (liability) holdings due to a depreciation of the nominal exchange rate. Hence the total change in the domestic-currency value of a foreign asset or liability stock, as reflected by the accruals-basis capital accounts in equations (A1.6) and (A1.8), is decomposed into its foreign-currency cash change (for instance, FA_{cb} in equation A1.6), and the capital gain due to an increase in the nominal exchange rate (RFA_{cb} in A1.6). Finally note that this procedure is consistent with the treatment of the relation between all foreign asset and liability stocks and flows in section 2.2 below, based on considering depreciation-induced capital gains and losses.

Appendix 1 presents all equations for interest payments.

A Flow of Funds Matrix for Zimbabwe, 1988

Using the most recently available data on budgetary and other public sector current and capital accounts, balance of payments flows, foreign debt stocks, monetary system assets and liability stocks, and national accounts flows, the six sectors' budget constraints were parameterized for 1988. A detailed discussion of (i) the available data sources, (ii) the criteria for selecting certain data sources over alternatives, and (iii) the data transformations, is presented in Appendix 2.

Combining the budget constraints with the current-price income-expenditure equation of the national accounts (equation B6.1 below), the flow-of-funds matrix for the 1988 base year is presented in table 2.2. Following standard RMSM-X presentations,³ the table displays the budget constraints divided into the current and capital accounts, each of them by sources of funds (rows) and uses of funds (columns).

2.2 Market Equilibrium Conditions and Behavioral Structure

Assets and goods markets equilibrium conditions and behavioral structure follow closely the specification and estimation results presented in our companion paper. Therefore the discussion here will be sparse, with exception of the treatment of financial asset accumulation equations, which are introduced only in this paper, and modifications on some of the estimated equations of our companion paper.

Asset Markets Equilibrium Conditions

The model notation does not distinguish explicitly between asset (liability) stock supplies and demands. The model distinguishes between 26 monetary and financial assets and one physical asset (physical capital).

³ See for instance Khadr et al. (1989) and Ventura (1990).

TABLE 2.2

SECTOR BUDGET CONSTRAINTS AND INCOME/EXPENDITURE EQUATION BY
CURRENT AND CAPITAL ACCOUNTS, SOURCES AND USES OF FUNDS: ZIMBABWE, 1988.

CURRENT ACCOUNT	Budgetary Gov't	Other Public Sector	Central Bank	Banking System	Private Sector	External Sector	National Accounts	Total Sources
Budgetary Government		Nob 120.3	Residcb 59.4		Td 1,795.9	COGb 0	Yfb 0 Ti 974.8 -Subb 0	3,908.9
Other Public Sector	Tbo 469.8					COGo 0	DRS -23.1	446.7
Central Bank	Nbcb 39.5	Nocb 23.6		Nbscb -4.5	Npcb 0	NFACb 18.4		77.0
Banking System	Nbbe 50.0	Nobs 84.8	NRes 0		Npbs 200.3	NFABs 1.7		336.8
Private Sector	Tbp 470.9 Nbp 365.6	Top 0 Nop 32.5	NNOLcb -4.9	NQM 133.7 NNOLBS 36.4 Residbs 164.1		Tfp 9.0 COGp 0	Yfp 9,690.3	10,897.0
External Sector	Nbf 192.3	Nof 40.8	NFLcb 4.3 NIMP 18.1	NFLbs 7.1	Npf 37.1 Nspf 44.2 PR 33.6 NKnei 0		-Exp -3,325.6 Imp 2,331.5	-15.6
National Accounts	Cb 2,449.8 Sb -128.9	Co 0 So 144.7	Scb 0	Sbs 0	Cp 5,500.5 Sp 2,327.5	Sf -45.7		10,247.9
Total Uses	3,909.0	446.7	76.9	336.8	10,897.6	-16.6	10,247.9	

CAPITAL ACCOUNT	Budgetary Gov't	Other Public Sector	Central Bank	Banking System	Private Sector	External Sector	National Accounts	Total Sources
Budgetary Government			Lcbb -32.1	Lbeb 184.2	Lpb 393.0	ROGb 106.7 Lfb 139.2	Sb -128.9	662.1
Other Public Sector	Lbo 158.1		Lcbo -31.0	Lbes 62.1	Lpo 112.4	ROGo 0 Lfo 0	So 144.7	446.3
Central Bank				Res 73.9 Cu 114.0	NOLcb -113.3	FLcb -14.6 RFLcb 9.2 IMP 153.4 RIMP 31.9	Scb 0	-52.3
Banking System			Lcbb -49.0		QM 240.2 MI 378.1 NOLbs 184.8	FLbs 2.0 RFLbs 17.3	Sbs 0	773.4
Private Sector			Lcbp 0	Lbep 327.8		ROGp 0 DFI 7.4 Lfp -485.5 LSfp 75.8 Knei 0 EO 289.8	Sp 2,327.5	2,542.5
External Sector			PACb -16.4 RFACb 76.2	PABs 3.8 RFABs 7.6			Sf -45.7	25.5
National Accounts	Ib 504.0	Io 446.3			Ip 962.0 Chetk 385.3			2,297.6
Total Uses	662.1	446.3	-52.3	773.4	2,542.5	25.5	2,297.6	

Interest rates of a few central monetary and financial assets clear the respective markets during the relevant period. Most other interest rates of domestic interest-bearing assets are fixed to these pivotal rates. Interest rates on foreign assets and liabilities are determined exogenously. All assets are assumed to be held voluntarily at current interest rates.

The asset market equilibrium conditions are reflected by the corresponding asset accumulation equations, relating asset stocks and flows, which are introduced next.

Financial/Monetary Assets Accumulation Equations

End-of-period domestic-currency financial or monetary assets (liabilities) increase over time by the simple accumulation equation:

$$(B1.*) \quad SL_{kj} = L_{kj} + SL_{kj,-1}$$

The change in the domestic-currency value of a foreign-currency denominated asset (or liability) involves foreign-currency accumulation and capital gains (or losses) components. The capital gains or losses are caused by changes in the nominal exchange rate. One capital gain or loss stems from the different timing of foreign currency accumulation in the budget constraints (valued at average-period exchange rates) as compared to the balance sheets (valued at end-of-period exchange rates). The second is due to the better-known annual (between end of periods) nominal exchange rate depreciation, which causes a gain (loss) on a foreign asset (liability) in proportion to the rate of devaluation.

Hence end-of-period domestic-currency values of foreign-currency denominated assets (or liabilities) increase over time as follows:

$$(B1.**) \quad SL_{kj} = E (SL_{kj}^* - SL_{kj,-1}^*) + RL_{kj} + SL_{kj,-1}$$

where the first term on the left-hand side reflects the foreign-currency (or cash) asset accumulation expressed in domestic currency units and the second term is the capital gain (or loss) due to exchange rate devaluations. The latter is

the sum of a timing capital gain (or loss) stemming from the above-mentioned difference between end-of-period and period-average exchange rates affecting the foreign-currency asset flow and the devaluation capital gain (or loss) stemming from the end-of-period exchange rate devaluation affecting the initial foreign-currency asset stock:

$$(B1.***) \quad RL_{kj} = E(SL_{kj}^* - SL_{kj,-1}^*) \left[\frac{E^* - E}{E} \right] + (E_{-1}^* SL_{kj,-1}^*) \left[\frac{E^* - E_{-1}^*}{E_{-1}^*} \right]$$

Note that only the first right-hand term of equation (4.**), the cash-base change, is reflected by budget equations (A1.1) - (A1.12), while end-of period domestic-currency valued foreign-currency holdings SL_{kj} on the left-hand side enter balance sheets.

Appendix 1 presents the 26 asset accumulation equations.

Physical Asset Accumulation Equation

Physical capital grows with net total domestic fixed-capital investment, which is equal to gross fixed investment (fi) less capital depreciation at an annual rate of 4.5%:

$$(B2.1) \quad K = (1 - 0.045) K_{-1} + fi$$

Asset Markets Behavioral Structure

The nominal interest rates on consolidated public sector domestic debt and on quasi-money are determined by the following portfolio equilibrium equations:

$$(B3.1) \quad \log\left(\frac{SH}{SB}\right) = a_0 + a_1 i_B + a_2 \log(y)$$

$$(B3.2) \quad \log\left(\frac{SM1}{SQM}\right) = b_0 + b_1 i_{QM} + b_2 \log(y)$$

The values of the coefficients of these and subsequent behavioral equations are listed in table 2.3, which is based on the simulation results of our companion paper. Most other domestic interest rates are anchored to these two rates by a set of equations introduced in Appendix 1.

